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ABSTRACT

A major purpose of this research was to measure the effect of four different teaching processes on lower and higher mental process achievement. Two separate studies, one in science and one in mathematics, involved approximately 100 seventh grade students in four classrooms in a public junior high school in a middle-income neighborhood, and 85 ninth grade junior high school students in a low-income neighborhood, respectively. Teachers of junior high level science and mathematics were trained to use higher mental process questions, with a goal of making at least 33 percent of questions asked higher mental process questions. Mastery learning procedures were incorporated in which students received feedback on their formative tests followed by corrective procedures and by parallel formative tests, which also included at least 33 percent higher mental process questions. Instructional material that posed higher mental process questions, problems, and illustrations were also used. Comparisons with students in control classrooms indicated that the experimental student groups made significant gains in higher and lower mental process achievement. Data from both studies support the hypothesis that student achievement is a function of the degree to which teaching processes used by a teacher provide adequate opportunities to learn higher mental processes. Three data tables and four figures are included. (CB)

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TEACHING PROCESSES TO IMPROVE BOTH HIGHER AS WELL AS LOWER MENTAL PROCESS ACHIEVEMENT

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Teaching Processes to Improve Both Higher as well as Lower Mental Process Achievement

This research addresses the persistent and widespread finding that education in the schools is primarily concerned only with the acquisition of information. While lower mental processes are of importance, in a rapidly changing world they are likely to be of less significance as compared to higher mental processes. A major purpose of this research was to determine the effect of four different teaching approaches on students' lower and higher mental process achievement.

The ability to solve higher mental process tasks is a desired educational outcome. Winne (1979) describes higher mental process performance as requiring the mental manipulation of bits of information previously learned to create or support an answer. In contrast, lower mental process performance requires memorization and rote learning.

Although the ability to analyze and apply knowledge is greatly valued, high levels of achievement on higher mental processes (HMP) are rarely found in conventional educational settings. Much of the time spent during classroom instruction continues to be focused on the memorization of facts. One reason for this is that most teachers find lower level processes easiest to teach. In this country, the majority of teaching methods, testing procedures and instructional materials emphasize the lower mental processes (LMP) (Bloom, 1978).

This emphasis on rote learning continues in schools throughout the United States where it is estimated that over ninety percent of the test questions public school students are asked require little more than information (Bloom, 1984). This problem of low attainment of higher mental processes has been pointedly demonstrated by the International Project for

the Evaluation of Educational Achievement which showed that in all the countries tested students perform best on the lower mental objectives, perform less well on objectives requiring interpretation or comprehension, and perform least well on higher level objectives involving application and inferences (Bloom, 1974).

In contrast, there are some schools in the world in which school subjects are taught as methods of inquiry and emphasis is placed on the underlying concepts and principles rather than on only the specific content to be remembered. The teaching and learning processes at such schools emphasize problem solving, application to new situations, analysis of situations, and creativity.

Research has shown that HMP can be learned by most students if they become more central in the teaching-learning-testing process. For example, Mevarech (1980) sought to improve higher mental processes by emphasizing heuristic problem solving and including higher and lower mental process questions in the formative testing and in the feedback-corrective process. She found the average student learning HMP under experimental conditions achieved above 90 percent of the control group. Levin (1979) found a way to improve higher mental processes by emphasizing mastery of principles and then providing opportunities for students to learn to apply these principles to new problems. Levin found that on HMP achievement, the average experimental student learning principles and their applications were above 98 percent of the control students who were only taught the principles.

Research done with one-to-one tutoring has also shown that when students are provided favorable learning conditions, the majority are able to perform HMP tasks. Anania (1981) found that the average LMP achievement

of students under tutoring was about two standard deviations above the average control class. In addition, Burke (1983) had the tutors emphasize HMP as well as LMP and found not only a two sigma solution on LMP but also on HMP. These two sigma solutions using tutoring suggest that when the opportunity to learn HMP is provided students can indeed learn higher mental processes.

Although tutoring is currently regarded as one of the best conditions for learning, it is not practical for widespread school use where resources and manpower are limited. Yet it can serve as a yardstick against which to measure the effect of more practical instructional conditions. The present research will attempt to demonstrate an improvement in both lower as well as higher mental processes to achieve the two sigma solution using a more practical, group instruction approach.

In this study, teachers were trained to ask higher mental process questions. The goal was to have them use at least thirty-three percent of classroom questions emphasizing higher mental processes. In addition, mastery learning procedures were incorporated in which students received feedback on their formative tests followed by corrective procedures and by parallel formative tests. The formative tests included at least thirty-three percent higher mental process questions and the correctives included both lower and higher mental process problems and tasks. Instructional materials which posed HMP illustrations, problems and questions were also used.

The thesis of the present research is that great gains in higher mental process achievement are possible if the teaching processes employed by a teacher provide adequate opportunities for students to learn higher mental

processes. Three variables of importance in teaching higher mental processes are examined: teachers' questions, feedback-correctives, and instructional materials. It was believed that emphasizing higher mental processes in the combination of these three variables - higher mental process classroom questions, feedback and correctives with higher mental process problems, and instructional materials including higher mental process emphasis - would result in greater gains in higher mental process achievement as compared with control conditions.

Method

Subjects. Two separate studies were conducted in science and math. The science study involved approximately 100 seventh grade students in a public junior high school located in a middle income neighborhood. The math study involved approximately 85 ninth grade students in a public high school located in a lower income neighborhood. Each study was conducted in four classrooms with each class consisting of approximately twenty to twenty-five students. Independently of this study, students were randomly assigned to classrooms using a computer program for class scheduling.

In each study, there were a few students who left school during the study or who had high absenteeism rates and were not present on testing days. In the science study, one or no students were dropped from each condition. In the math study, three to five students were dropped from each condition. Loss under the different conditions were roughly proportionately equal.

Procedure. In each study, one control and three experimental groups were compared (see Fig. 1). The control condition approximated conventional instruction where the teacher taught the course as usual. The procedures

used were those found in many classrooms typically involving the teachers' use of predominately lower cognitive classroom questions as well as instructional materials consisting of mostly lower cognitive tasks. In the minimal opportunity to learn higher mental processes (HMP), teachers asked at least one-third higher cognitive classroom questions and used the same instructional materials as the teachers in the control condition. In the intermediate opportunity to learn HMP, a mastery learning feedback-corrective procedure was employed which had at least one-third higher mental process questions, and instructional materials were used which included at least one-third higher cognitive problems, illustrations, and tasks. In this condition, teachers' classroom questions were predominately at the lower cognitive level. In the maximal opportunity to learn HMP, at least one-third of teachers' questions emphasized HMP; feedback-corrective procedures included at least one-third higher cognitive material; and instructional materials also included at least one-third higher cognitive problems and tasks.

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insert Figure 1

The science study was conducted over a four week period and incorporated three sequential learning tasks. The math study was conducted over eight weeks and incorporated four sequential learning tasks. Each class met daily for a period of forty-five to fifty-five minutes. Instructional materials were used in the classroom instruction during those periods. Following the last period of instruction, a formative test was given. Students in the intermediate and maximal conditions who did not

initially meet the predetermined criterion level used the test as feedback for the learning task and as a diagnostic for corrective procedures. An alternate form of the test was then administered and students who still did not meet the criterion of eighty percent repeated the feedback-corrective procedure for the items missed. Students in the control and minimal conditions did not receive any treatment following the formative test. A summative test of achievement which covered all of the content covered in the learning units was given at the end of each study.

Instructional materials were adapted from textbooks. Problems, tasks and test items were classified as either LMP or HMP according to the levels defined in the Taxonomy of Educational Objectives.

Two teachers participated in each study. Each taught two classes with two different settings. The same teacher instructed students in the control setting, which employed questions emphasizing LMP and in the intermediate setting, which employed the same questions plus feedback-correctives and instructional materials emphasizing HMP. Another teacher instructed students in both the minimal condition, which involved teachers' questions emphasizing HMP, and the maximal condition which employed the same questions as the minimal condition plus included feedback-correctives and instructional materials emphasizing HMP. This design insured that teachers' use of questions emphasizing HMP were consistently used in the teaching approaches which enhanced this component and that they were not used with the other teaching approaches. The same teacher was used across two conditions (either control and intermediate, or minimal and maximal) since the use of a feedback-corrective procedure and instructional materials followed each learning units and did not affect the process of teaching and

learning of the units' content. This design was employed in order to minimize the training period and in order to prevent confusion of the two different questioning strategies by the teacher. The researcher monitored the teachers two periods per week to insure that each asked the appropriate level of questions.

Instrumentation. In this study both higher and lower cognitive achievement were of interest. Achievement was the level of learning exhibited by students on formative and summative tests. In the science study, LMP achievement included knowledge and comprehension types of questions. HMP achievement included questions at the application and analysis levels of the taxonomy. In the algebra study, LMP included knowledge of facts, terminology, rules and mathematical structures. HMP in algebra included the ability to transfer problems, follow reasoning, solve problems involving a sequence of responses from the student (application), and go beyond what was done during previous instruction (analysis).

Formative tests based on the content and objectives of the learning tasks were given following each learning task. The tests were composed of both higher and lower cognitive items. These tests were used for diagnostic purposes for students in treatments employing feedback and correctives. They provided information concerning the extent of learning which had taken place and indicated where correctives were needed. For students not engaged in feedback-correctives, the formative test was used as a quiz and students received information only on their total test score. Final achievement was measured by a summative test composed of lower and higher cognitive items. This summative test was given to all students at the completion of the series of learning tasks.

Each formative and summative test consisted of at least thirty-three percent higher mental process questions. Selection of items was based on the content and objectives of all the units studied and was made by all teachers who participated in each study. Only items for which full agreement had been reached by the teachers in each study were included in the examinations.

In order to determine possible differences of the four classes in each study, students' prior achievement was compared. In the seventh grade, prior achievement was operationalized as teachers' grades in the science class for the quarter ending prior to the start of this study. In the ninth grade prior achievement was operationalized as the test score average for six weeks of instruction in math taught prior to the study.

Results

The comparison of initial means and standard deviations among the groups in summarized in Table 1. The random assignment of students to classrooms resulted in comparable means and standard deviations for the four conditions within each study. Since there were no significant differences between the groups ($p < .05$) it was concluded that the groups were initially comparable on these prior achievement measures.

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insert Table 1

For all analyses, the dependent variable achievement was reported in terms of percent correct. To determine the significance level among the higher and lower cognitive achievement means for each formative test and the summative tests, Scheffe's multiple comparison was used.

Table 2 reports the mean scores and standard deviations of lower and higher mental process achievement on the summative test for all groups in both studies.

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insert Table 2

Levels of summative achievement were higher for the minimal opportunity to learn HMP in which the only instructional difference from the control was the teachers' use of at least one-third HMP questions. In both the algebra study and the science study these differences are about .8 sigma on HMP and also .8 sigma on LMP. This means the average student in the minimal learning opportunity outperformed 79 percent of the students in the control condition on both higher and lower mental processes.

Particularly noteworthy of these results is that even in this minimal opportunity to learn HMP which emphasized HMP in only one variable, teachers' classroom questions, the differences in both HMP as well as LMP achievement (as compared to the control group) are almost at the same level as those found under mastery learning. Furthermore when at least one-third HMP teacher classroom questions are used there is a very significant gain on higher mental processes which is accompanied by a corresponding gain in the lower mental processes.

Even higher mean levels of summative achievement were found for students who received the intermediate opportunity to learn HMP which made use of a feedback-corrective procedure and instructional materials both which included at least one-third higher cognitive material. In this condition teachers' classroom questions were primarily at the LMP level.

The average differences between this group and the control group on algebra and also science HMP achievement was about 1.1 standard deviations and about 1.2 standard deviations on LMP. In other words, the average student in the intermediate condition outperformed 86 percent of the students in the control condition on higher mental processes and 87 percent on lower mental processes.

The highest levels of summative achievement were found for students who received the maximal opportunity to learn HMP with at least one-third HMP teacher questions, a feedback-corrective procedure having at least one-third higher cognitive materials, and instructional materials with at least one-third higher cognitive tasks. The average differences between the maximal and control group for the algebra and science studies was about 1.8 sigmas on HMP and 1.6 sigmas on LMP achievement. This means the average student in the maximal learning opportunity outperformed 96 percent of the students in the control condition on higher mental processes and 95 percent on lower mental processes.

Most striking about these results is that when higher mental processes are emphasized in all three variables, the effects on learning are even greater than when only one or two variables are used. Under these superior teaching/learning conditions the HMP and LMP levels of achievement are close to those found under one-to-one tutoring. Thus it appears that as different amounts of emphasis on HMP are employed, differential effects on student achievement are found.

Figure 2 demonstrates that in addition to the highest levels of HMP achievement being attained by students in the maximal conditions, the highest levels of LMP achievement were also attained. What is startling

about these results is the finding that taking time away from teaching lower mental processes in order to spend more time teaching higher mental processes improves the learning of both the lower mental processes as well as the higher mental processes. As increased time and emphasis are placed on teaching higher mental processes, the increased gains on HMP achievement are accompanied by very similar gains on LMP achievement. It appears that learning HMP enables the student to learn LMP even better.

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insert Figure 2

To determine the effects over a series of learning tasks, Table 3 compares the means and standard deviations of LMP and HMP achievement for the formative and summative tests. In both studies student achievement in the minimal condition is consistently greater than in the control condition. This difference is apparent at the beginning of the studies on the first formative test and becomes increasingly larger over the duration of the studies. The variable differentiating these two conditions was the teachers' use of classroom questions. In the control conditions teachers' classroom questions were primarily at the LMP level. In the minimal conditions, teachers asked at least one-third of their classroom questions at the higher cognitive level.

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insert Table 3

Similarly, achievement in the maximal condition is consistently greater than the intermediate condition in both studies. This difference again

appears on the first formative test and increases over the duration of the studies. Both of these conditions involve the use of mastery learning and instructional materials involving at least one-third HMP problems, illustrations, and tasks. What differentiates these two conditions is the type of questions teachers ask. In the intermediate condition, teachers asked primarily LMP classroom questions while in the maximal condition teachers asked at least one-third of their questions at the higher cognitive level.

Comparison of the minimal with the maximal opportunity indicates that achievement for the maximal condition is consistently higher then for the minimal condition over time following the second learning task. Both of these conditions involve the use of at least one-third HMP teachers' questions. On the first formative test the achievement of the two groups are roughly comparable with the maximal group having a very slight edge over the minimal group. This may be due to the instructional materials involving HMP used by the maximal group. Following this first test the maximal group engaged in a feedback-corrective procedure. This use of mastery learning is a major factor differentiating these two groups and results in consistently greater achievement over subsequent learning tasks.

The differences between the minimal and intermediate conditions change over time. The minimal opportunity employs the use of at least one-third HMP classroom questions, and initially results in greater achievement for this group than for the intermediate group. About halfway through each study however, the effect of mastery learning in combination with the instructional materials employing at least one-third HMP problems, eventually surpasses the effect of HMP questions alone. This results in

greater achievement for the intermediate as compared to the minimal conditions toward the end of each of the studies.

The maximal learning opportunity, as a result of emphasizing HMP in all three instructional variables, exhibited the highest achievement over the length of the study. The intermediate learning opportunity employing predominately LMP questions with HMP emphasis in feedback-correctives and instructional materials exhibited higher achievement and lower variation than the minimal group as a result of emphasizing HMP in two instructional variables. The minimal learning opportunity employing at least one-third HMP questions exhibited achievement higher than the conventional group as a result of HMP emphasis in one instructional variable. The overall effect of providing greater opportunities to learn HMP is well demonstrated in the results of both studies involving two different subject areas.

Figures 3 and 4 illustrate the results reported in Table 3, and in addition highlight the differential effects on achievement for the same teacher. In each study, one teacher teaching the control and intermediate conditions (represented by dotted lines) got very different results over the series of learning tasks. The other teacher in each study, teaching the minimal and maximal conditions (represented by solid lines) had similar patterns of differences over the series of learning tasks. While each teacher taught using two different approaches, each got better results with the superior method of teaching both HMP as well as LMP.

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insert Figures 3 & 4

Discussion

The purpose of this study was to determine the effect of teaching processes on lower and higher mental process achievement. The four different teaching approaches led to four different opportunities to learn HMP and resulted in differential effects on achievement. It is clear that the more emphasis given to higher mental processes in the teaching-learning process, the closer we approach the two sigma solution. That is, under the maximal opportunity to learn HMP students can attain levels of achievement on lower as well as higher mental processes which approximate the effectiveness of one-to-one tutoring.

Under the maximal opportunity, which emphasized HMP in teachers' questions, feedback-correctives, and instructional materials, the average student on HMP achievement was above 96% of the students in conventional classes. In addition, these students were above 95% of the control class on LMP achievement. The average student in the intermediate condition, which emphasized HMP in feedback-correctives and instructional materials, was above 85% of the students in the conventional classes on HMP achievement and above 86% on LMP achievement. In the minimal condition when the teachers' questions emphasized HMP, the average student on HMP achievement was above 79% of the control students and above 77% on LMP achievement.

The data presented from both studies support the hypotheses that student achievement is a function of the degree to which the teaching processes employed by a teacher provide adequate opportunities to learn higher mental processes. The lowest levels in both lower and higher mental processes achievement occurred under conventional instruction. This type of instruction is typical of that most often found in schools where there is

great emphasis on lower mental process learning. In contrast, the highest levels of achievement occurred under maximal conditions where higher mental processes were emphasized in teachers' questions, feedback-correctives, and instructional materials.

These results demonstrate that different teaching-learning conditions produce different results for the same teacher. The main implication of this research is that the teaching method employed by a teacher determines the effectiveness of students' lower and higher mental process achievement. Initially the achievement for two groups taught by the same teacher was very similar. Teachers were randomly assigned to these teaching conditions and then each was helped by the researcher to learn how to employ the appropriate classroom questions, feedback-correctives, and/or instructional materials. At the end of the studies each teacher teaching under two different conditions had significantly better results (on both HMP and LMP achievement) by the teaching method which had greater emphasis on the higher mental processes. It was evident in these studies that teachers could learn to use one or more of these instructional methods of teaching HMP. If teachers are given similar teaching-learning conditions, most should be able to improve both lower and higher mental process student achievement to a very high level.

Most striking and surprising are the results that increasing emphasis on higher mental process instruction results <u>not only</u> in increases in HMP achievement but also in very similar increases in LMP achievement. What is startling about these results is that improving HMP is not at the expense of LMP. It is believed that the process of solving HMP problems and tasks requires the student to become more actively involved in learning which in

turn creates interest, enthusiasm and excitement: HMP teaching makes learning come alive. It is clear that when a student can apply learning to new situations that understanding is also improved.

Several limitations concerning the extent to which the findings of these studies can be generalized must be considered. One consideration concerns the sample which participated in the studies. Students in both studies attended public schools; one school was located in a middle-income neighborhood and the other was located in a lower-income neighborhood. While these schools and students do not represent a random sample of the student population in the United States, it is believed that similar results would be demonstrated in other populations.

The magnitude of the results is somewhat surprising, considering the studies lasted for four or eight weeks. Had the studies been conducted for a longer period of time, it is possible that the effects found in both studies would have been further confirmed and even strengthened.

Further research needs to be done to see if the effect of these teaching methods apply to other grade levels, other samples of the school population, and other content areas such as art, music, literature, and social studies. The two content areas demonstrated in the present research both involve highly sequential learning tasks. While it is likely that in other content areas employing sequential learning tasks similar results would be found, additional research is needed to determine whether the results would hold with other content areas which are not highly sequential.

A final concern involves the observation and monitoring of the teachers' questions by the researcher. Further research is needed to determine whether similar results would appear when these instructional

methods are employed on a larger scale without the presence of the researcher.

These results are of importance because they have been found using different content areas, different grade levels, and different teachers. This approach to improving student achievement is likely to be regarded as widely applicable because the use of higher mental processes for other courses is likely to be similar even if different teachers, different grade levels, and different subject areas are involved.

In summary, the main contribution of these studies was the development of teaching methods for group instruction which are as effective as one-to-one tutoring in improving higher, as well as lower, mental process achievement for most students. The effectiveness of each method is in relation to the amount of emphasis on HMP. In each study, each teacher taught using two different approaches. The teachers were able to learn to teach using both approaches. In each case, the teacher got better results on both HMP and LMP by using the teaching method which had greatest emphasis on HMP. Ideally, most teachers can make use of the most powerful method of teaching HMP to improve the higher as well as lower mental process achievement of their students.

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TABLE 1

PERCENT MEANS AND STANDARD DEVIATIONS FOR PRIOR ACHIEVEMENT

Groups: Opportunity to learn HMP[1]		Ninth Grade/Algebra Test Score Average[2]	Seventh Grade/Science Teachers' Grades[3]
Setting D: Maximal	$\bar{x}$	89.40	2.16
	s	5.25	1.05
	n	20	24
Setting C: Intermediate	$\bar{x}$	87.75	2.16
	s	7.93	.93
	n	21	25
Setting B: Minimal	$\bar{x}$	89.72	2.04
	s	6.36	1.33
	n	20	25
Setting A: Control	$\bar{x}$	88.66	2.30
	s	8.39	1.14
	n	20	24

[1] No two groups are significantly different at the .05 level ($p < .05$).

[2] Test score average for three instructional units taught prior to the beginning of the study.

[3] Teachers' grades for the quarter ending prior to the beginning of this study.

TABLE 2

PERCENT MEANS AND STANDARD DEVIATIONS OF HIGHER AND LOWER COGNITIVE ACHIEVEMENT ON THE SUMMATIVE TEST

Opportunity to learn HMP		Ninth Grade/Algebra		Seventh Grade/Science	
		LMP	HMP	LMP	HMP
Setting D: Maximal[1]	$\bar{x}$	83.33	74.59	88.96	81.35
	s	10.96	12.54	13.16	15.36
	f	(1.8)	(1.9)	(1.4)	(1.7)
Setting C: Intermediate[2]	$\bar{x}$	74.61	61.03	79.84	72.48
	s	14.43	13.38	14.95	16.93
	f	(1.3)	(1.0)	(.9)	(1.2)
Setting B: Mimimal[3]	$\bar{x}$	67.78	57.10	75.36	65.36
	s	16.48	16.06	18.19	18.88
	f	(.8)	(.8)	(.7)	(.8)
Setting A: Control	$\bar{x}$	54.68	45.61	61.83	49.33
	s	15.64	15.31	19.28	19.25

effect size $f = \dfrac{\bar{x}_{treatment} - \bar{x}_{control}}{s_{control}}$

[1] Teachers' questions (one-third HMP)
Feedback-correctives (one-third HMP)
Instructional material (one-third HMP)

[2] Feedback-correctives (one-third HMP)
Instructional material (one-third HMP)

[3] Teachers' questions (one-third HMP)

TABLE 3

PERCENT MEANS AND STANDARD DEVIATIONS FOR FORMATIVE AND SUMMATIVE ACHIEVEMENT

Formative test		FT1A		FT1B		FT2A		FT2B		FT3A		FT3B		FT4A		FT4B		SUMMATIVE	
Level of achievement		LMP	HMP	LMP	HMP	LMP	HMP	LMP	HMP	LMP	HMP	LMP	HMP	LMP	HMP	LMP	HMP	LMP	HMP
Ninth Grade/Algebra																			
Setting D: Maximal[1]	$\bar{x}$	78.5	57.4	91.9	83.0	69.3*	63.3*	80.8	78.9	82.2*	77.8*	97.2	88.8	83.9*	68.3*	96.7	89.5	83.3*	74.6*
	s	12.2	15.6	7.5	12.8	14.9	24.2	14.8	20.0	14.2	22.8	4.7	15.7	17.8	16.4	7.3	10.9	11.0	12.5
Setting C: Intermediate[2]	$\bar{x}$	71.2	46.2	84.1	69.5	58.7*	43.4*	74.3	67.8	71.0*	58.1*	83.7	71.8	75.1*	59.3*	92.1	82.4	74.6*	61.0*
	s	14.4	23.4	12.2	18.1	22.4	26.0	19.2	17.5	14.9	12.5	9.4	16.9	17.5	16.1	8.7	13.7	14.4	13.4
Setting B: Minimal[3]	$\bar{x}$	76.1	56.5			66.0*	53.3*			70.6*	56.1*			68.4*	50.0*			67.8*	57.1*
	s	13.4	13.8			16.8	22.7			14.5	17.9			20.8	18.8			16.5	16.1
Setting A: Control	$\bar{x}$	68.6	48.9			50.8	31.7			56.0	43.3			57.2	36.3			54.7	45.6
	s	17.1	17.1			13.3	24.0			16.0	22.5			17.0	21.1			15.6	15.3
Seventh Grade/Science																			
Setting D: Maximal[1]	$\bar{x}$	73.8	70.5*	87.3	80.6	81.1*	77.4*	90.9	87.1	83.6*	81.5*	92.0	88.5					89.0*	81.4*
	s	17.4	19.3	13.5	16.1	14.8	16.6	12.0	13.7	13.8	14.7	10.4	11.8					13.1	15.4
Setting C: Intermediate[2]	$\bar{x}$	65.4	53.7	82.4	71.8	70.3*	62.0*	84.9	74.6	76.8*	69.2*	88.6	81.6					79.8*	72.5*
	s	19.7	21.1	14.9	17.0	18.3	20.2	15.2	16.1	18.1	16.2	12.5	12.1					15.0	16.9
Setting B: Minimal[3]	$\bar{x}$	73.5	69.3			70.0*	62.8*			73.0*	62.2*							75.4*	65.4*
	s	18.0	19.0			18.7	19.1			17.8	18.9							18.2	18.9
Setting A: Control	$\bar{x}$	66.2	58.7			60.2	48.3			56.5	47.1							61.8	49.3
	s	21.1	20.3			20.3	19.7			22.1	19.6							19.3	19.3

* $p < .01$

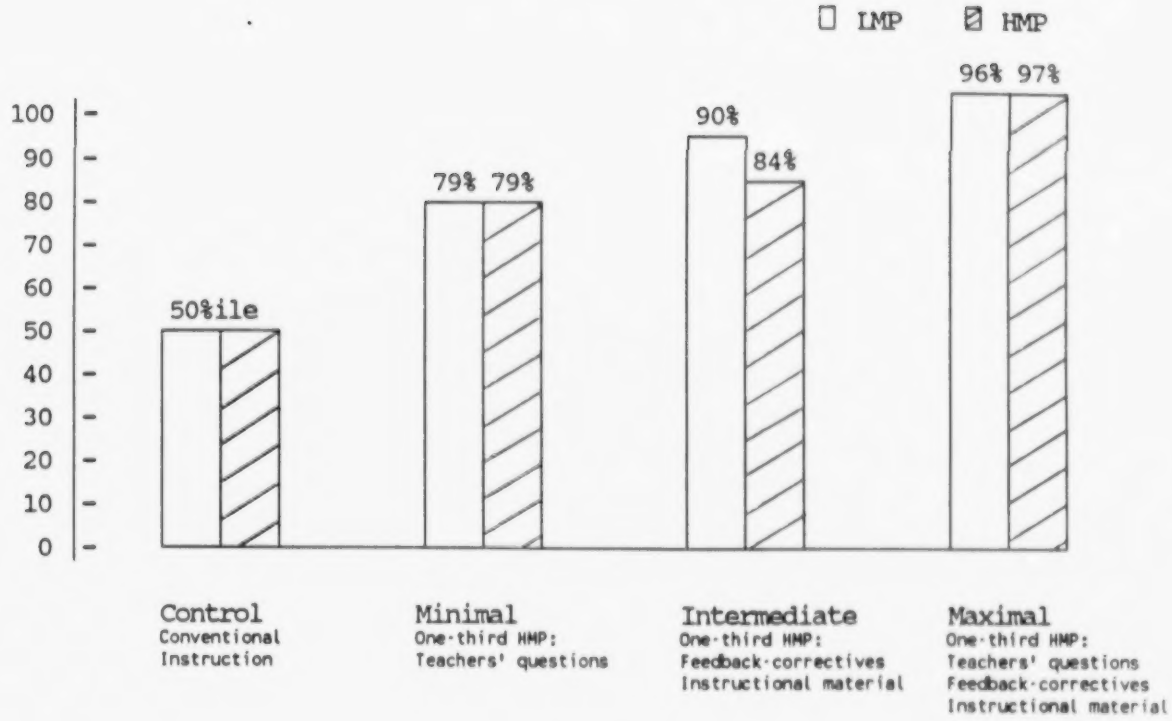
[1] Teachers' questions (one-third HMP)
Feedback-correctives (one-third HMP)
Instructional material (one-third HMP)

[2] Feedback-correctives (one-third HMP)
Instructional material (one-third HMP)

[3] Teachers' questions (one-third HMP)

Control	Minimal
LMP Questions Absence of feedback correctives Instructional material emphasizing LMP	LMP and HMP Questions Absence of feedback correctives Instructional material emphasizing LMP
Intermediate	**Maximal**
LMP questions LMP and HMP feedback correctives LMP and HMP instructional materials	LMP and HMP questions LMP and HMP feedback correctives LMP and HMP instructional materials

Figure 1. Typology of conditions.



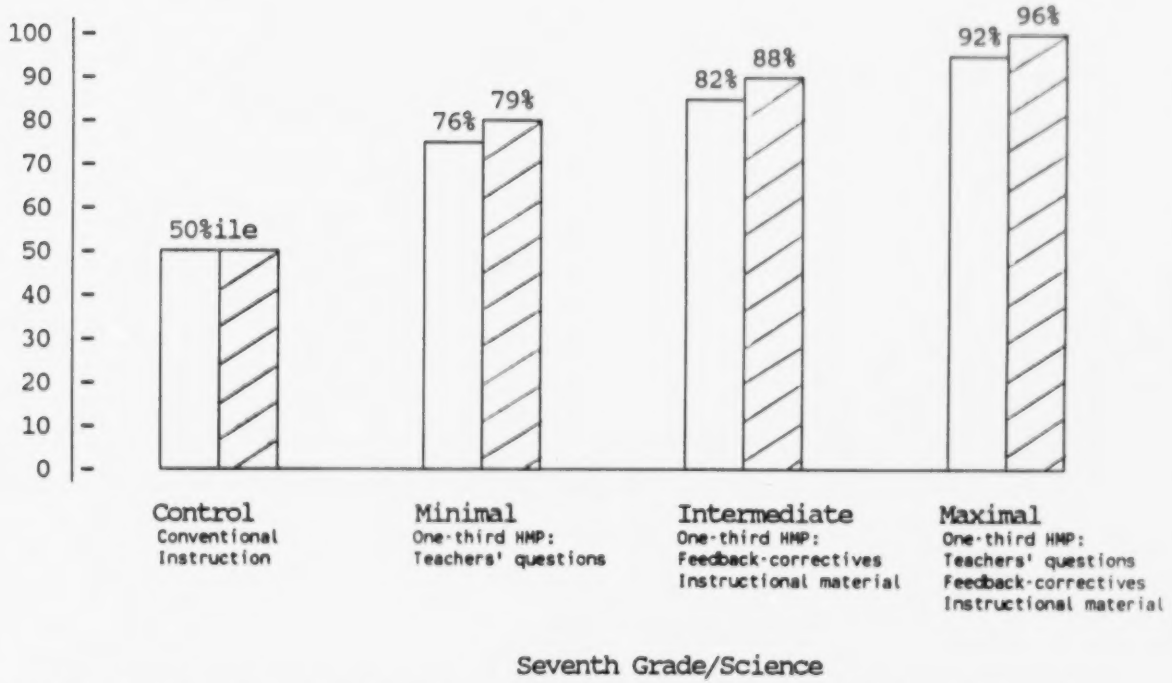
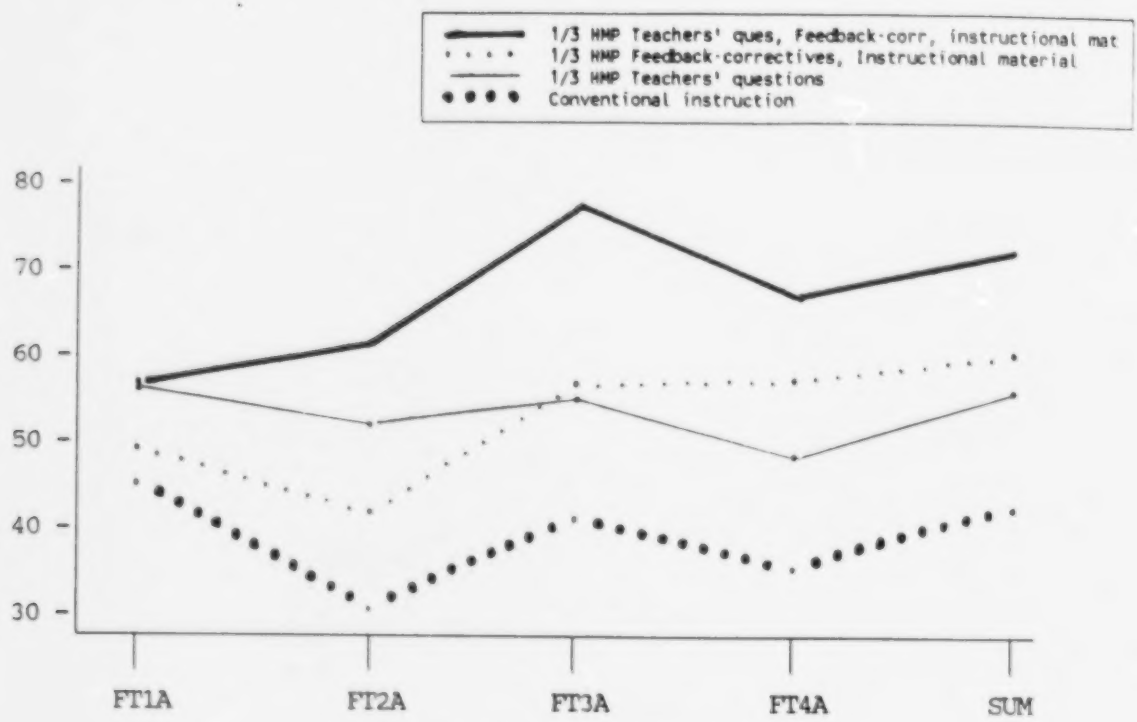


Fig. 2 Lower and higher mental process achievement under different learning conditions in algebra and science.



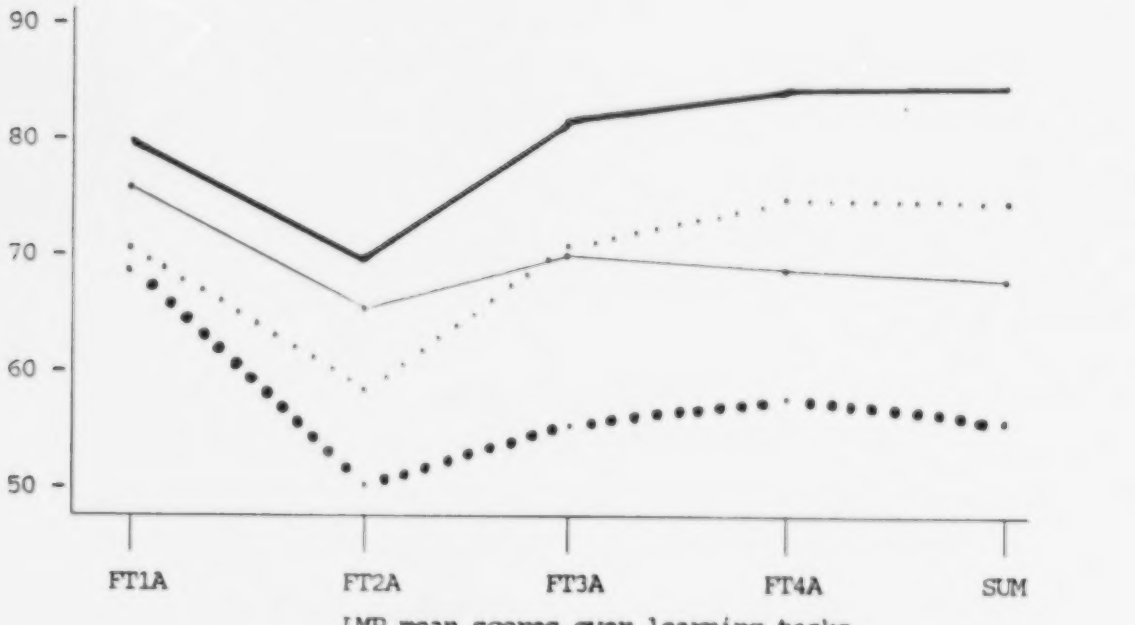
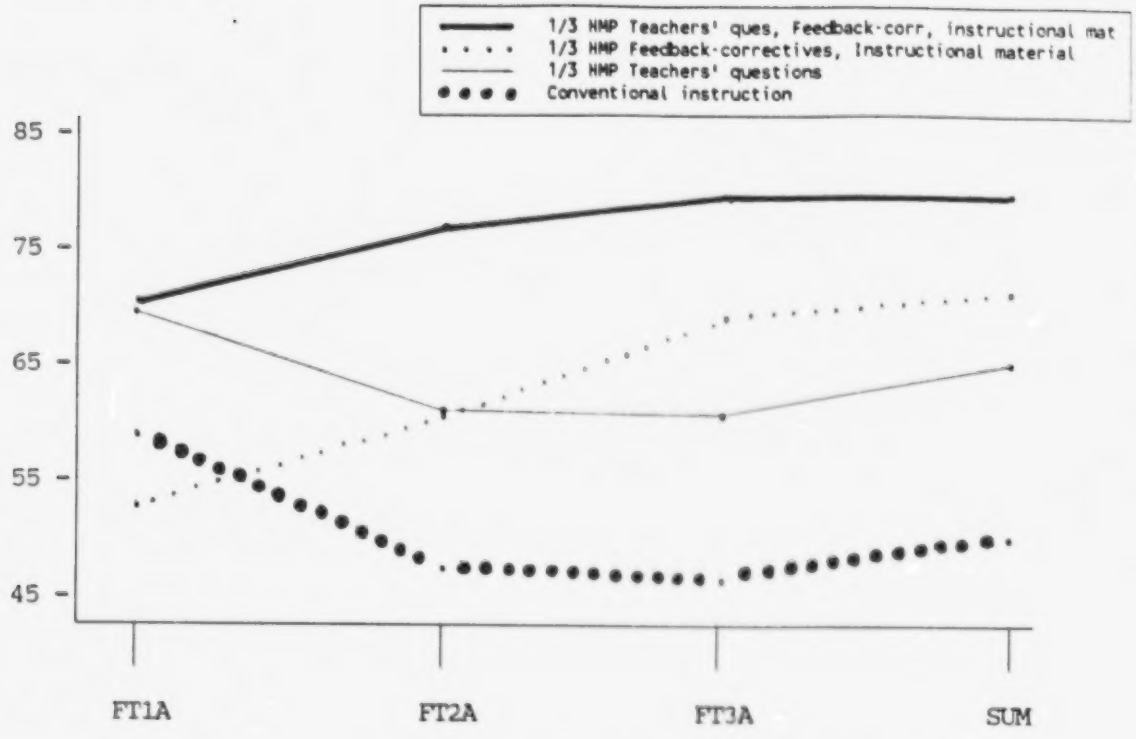
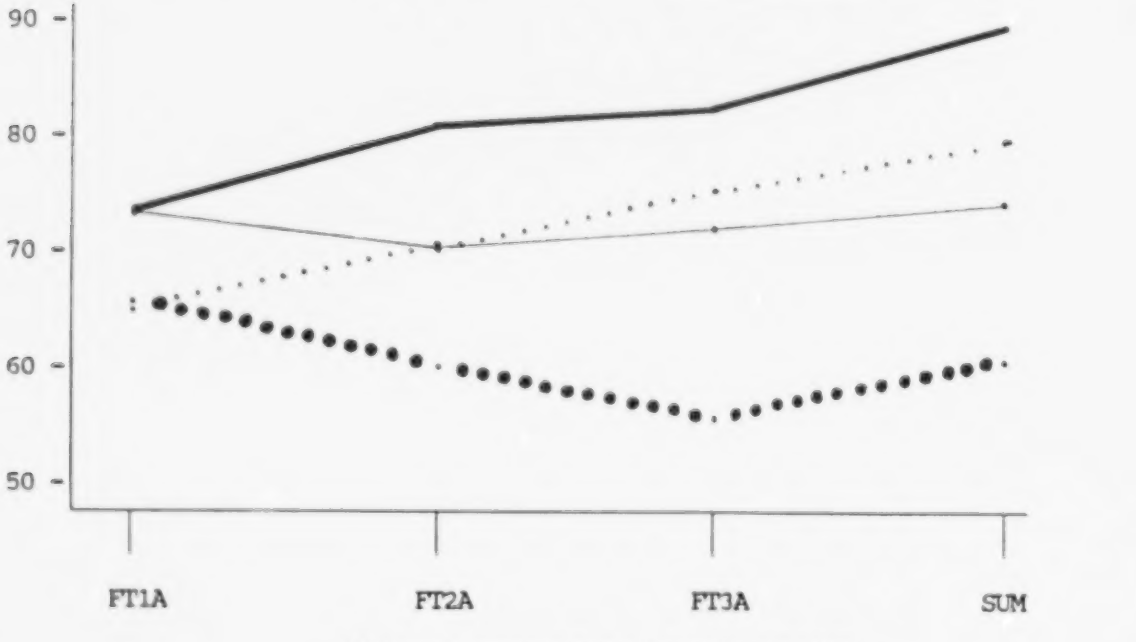


Fig. 3 Changes in achievement over learning tasks for Ninth Grade/Algebra.



HMP mean scores over learning tasks



LMP mean scores over learning tasks

Fig. 4 Changes in achievement over learning tasks for Seventh Grade/Science.